MEASURING THE CONTRIBUTION OF DEADWOOD RESPIRATION TO TOTALECOSYSTEM C EXCHANGE AT THE HOWLAND RESEARCH FOREST, HOWLAND, ME.

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ABSTRACT

Deadwood is an important part of a healthy forest that has long been overlooked when considering ecosystem respiration. The microbes involved in the decomposition of deadwood produce CO2 and contribute to the carbon budget, and this is currently being researched at the Howland Forest in Maine. The intent of this study is to find the rate of respiration taking place in decaying deadwood.

After four weeks of sampling, we have found that deadwood respiration, when compared to soil respiration on an aereal basis, contributes a considerable amount of CO2. We eventually will seek a relationship between deadwood respiration and temperature, water content, nitrogen content, and decay class within each species.

INTRODUCTION

The importance of deadwood to a healthy forest has long been overlooked despite being a conspicuous part of most forest ecosystems. Deadwood serves as habitat and resource to many insects and microbes, is a seedbed for plants, can store nutrients and water, and reduce erosion. Insects, bacteria, and fungi decompose deadwood and release the nutrients into the environment. Decomposing woody material can act as either a nutrient sink or source, depending on the nutrient under consideration, the quality of the deadwood, biotic activity, nutrient inputs, and stage of decomposition.

Deadwood decomposition by heterotrophic microorganisms produces carbon dioxide as a byproduct of carbon mineralization, and should be considered in the C budget of any ecosystem containing this substrate. The slow decomposition and persistence of woody materials on the forest floor, and the difficulty of degrading remaining lignaceous compounds, however, results in this C pool often being minimized in models of the C cycle (Fig. 1). Because of the large amount of deadwood present in the maturing red spruce and northern hemlock-dominated forests in central Maine, we chose to measure deadwood respiration to estimate its contribution to overall ecosystem respiration and thus C exchange at this northern forest. We made deadwood respiration measurements and intend to compare these data with other information including the water content of the decaying logs, temperature, decay class and eventually the nitrogen content.

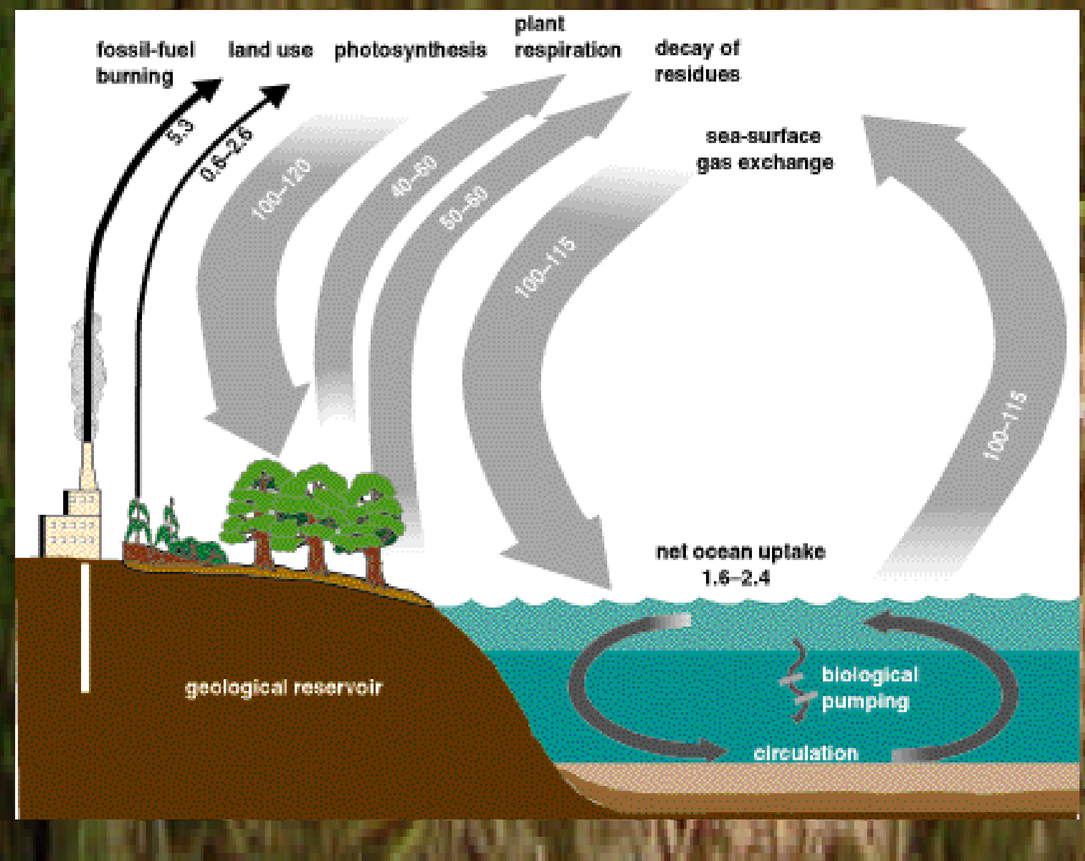


Figure 1. Typical model of the terrestrial and aquatic C cycle

Hypotheses

- *Does respiration depend on the concentration of water in the sample?*

Bacteria and fungi, which are the main decomposers of woody material, need water to obtain nutrients, but excess water may limit oxygen diffusion and thus the oxidative metabolism of most heterotrophic decomposers. When graphing %water vs. ppm CO_2, we might expect to see a gaussian curve representing ideal water conditions for microbial activity and reduced respiration at the extremes of too little or too much water activity.

- *Does respiration depend on decay class?*

A predicted relationship exists between decay class and %water, and so respiration should increase as decay class increases. Also decay class 4 contains more insects, and insect galleries that increase the surface area exposed to leaching and decomposing microorganisms.

- *Does respiration depend on temperature?*

A higher temperature results in a greater respiration, so long as water content is held constant.

- *Does respiration depend on the amount of nitrogen available?*

Fungi and bacteria need nitrogen and this is usually obtained from elsewhere in the environment besides the deadwood as this source has high C:N initially and is a poor source of N compared to surrounding soil. Trees only contain around 1% N, but when they start to decay, the C to N ratio decreases because wood C is being mineralized, but most of the N is not being used by the microbes or microbes may immobilize N from soil directly into the decaying wood. At later stages of decay, a lower C:N ratio could increase microbial activity and thus decay and respiration.

- *Does respiration depend on the amount of soluble carbon available?*

There are two main sources of carbon in deadwood – cellulose and lignin. The lignin is like the glue holding the cellulose together, and is therefore hard for microbes to digest. Only certain bacteria and fungi are capable of doing this, and so as the deadwood becomes more decayed, the lignin to cellulose ratio increases, and this may slow down respiration because not as many organisms are able to extract the carbon from lignin. This of course, is antagonistic to hypothesis #3.

METHODS

Research Site:

The Howland Forest research site is located about 35 miles north of Bangor, ME at 45° 12' N, 68° 44' W at an elevation of 60 m. Howland is an Ameriflux site where Eddy covariance techniques are used to measure net ecosystem C fluxes by way of towers extending above the canopy.

Field Methods:

Fir and spruce deadwood samples were taken using a handsaw (Fig. 2) and put into one of the modified USFS decay classes, which are as follows:

Class1: Wood is sound and cannot be penetrated with thumbnail; bark intact; smaller to medium-sized branches present; log often suspended by its branches.

Class 2: Wood sound to somewhat rotten; bark may or may not be attached; branch stubs are firmly attached but only larger stubs are present; log retains round shape and lies on duff.

Class 3: Wood substantially rotten, enough that branch stubs pull out easily and thumbnail penetrates readily; wood texture soft and may be 'squishy' if moist; bark lightly attached, sloughing off or detached; bole assuming a slightly oval shape and may be partly buried in duff.

Class 4: Wood mostly rotten, 'fluffy' when dry and 'doughy' when wet; branch stubs rotted down; bark detached or absent (for most species); decidedly oval in cross-section and, usually, substantially buried in duff. NOTE: The lower cut off point for this class occurs when top of log has been lowered by decay to the general DUFF level at its sides – making it indistinguishable, except for traces of decayed wood, bark (some species) or plant covering, from the surrounding duff.

This sample is then put into a respiration chamber (an air-tight plastic container of 13.1 L) (Fig. 3) that is attached to a LICOR CO2 analyzer (Fig. 4), and the concentration of carbon dioxide is recorded every thirty seconds. This slope of the linear regression of CO2 concentration with time is used to calculate the rate of microbial respiration in the wood. This CO2 production rate can be expressed per unit of dry or wet wood and extrapolated to a hectare basis using data from the site on dead wood stocks.

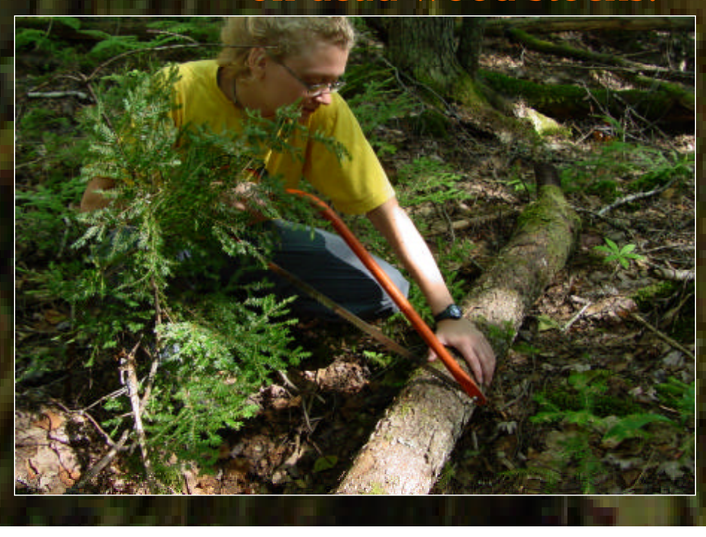


Figure 2. Collecting the sample

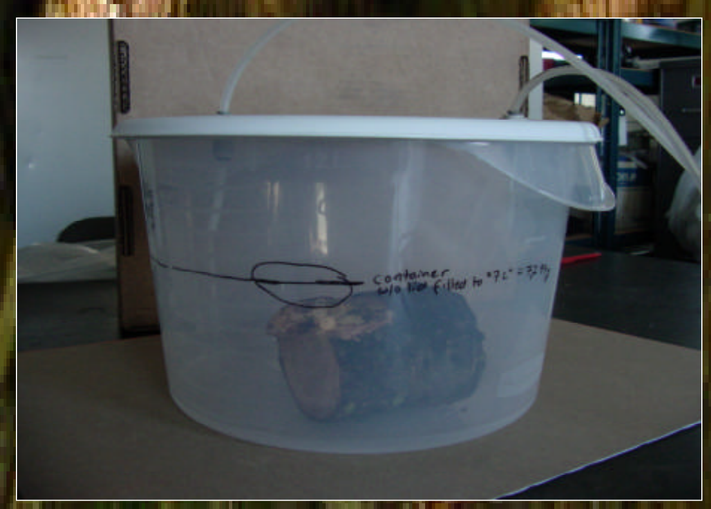
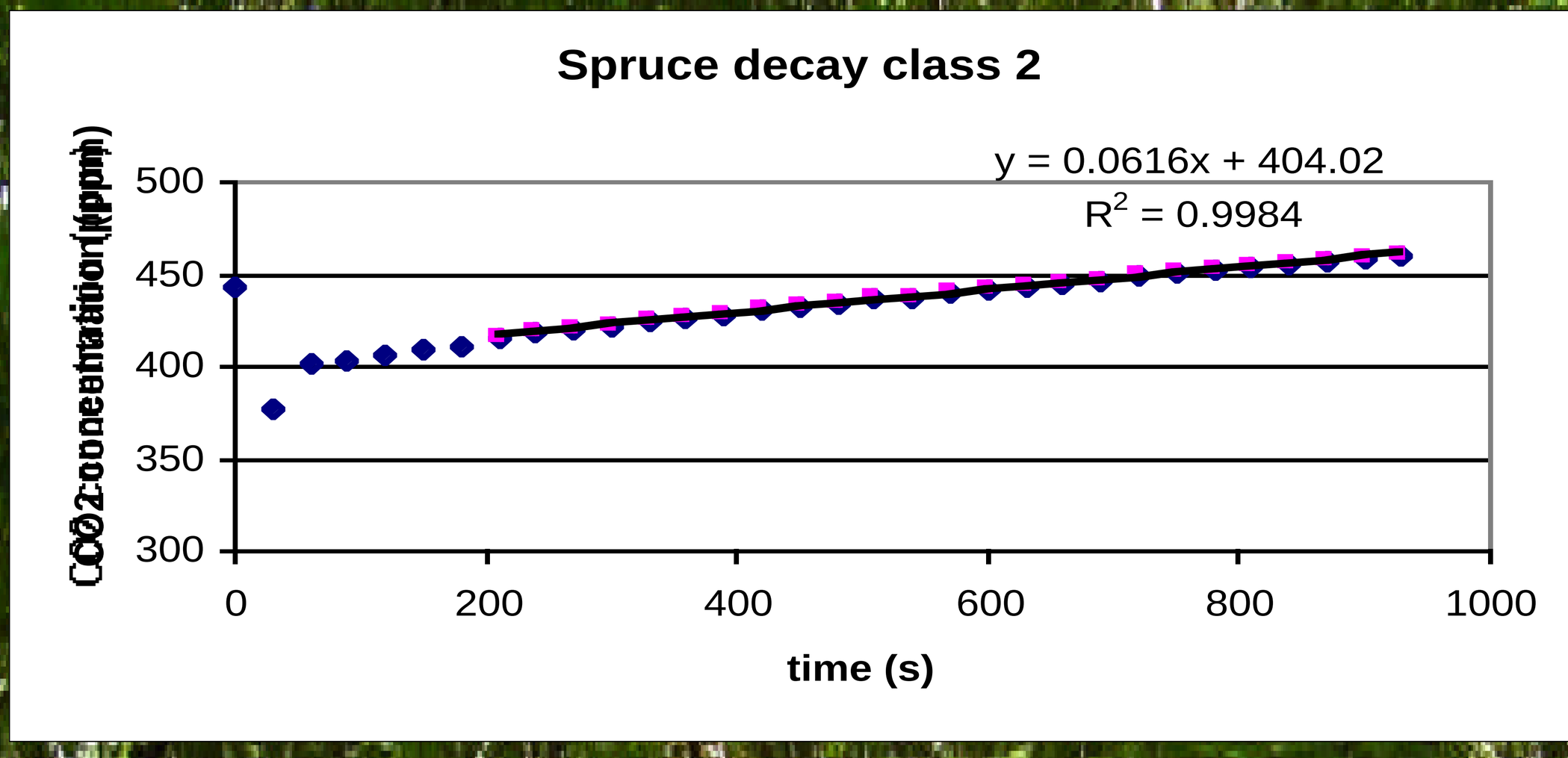


Figure 3. The respiration chamber

Figure 4. The LICOR CO2 analyzer setup

Samples were weighed wet and volume measurements were taken by water displacement and also geometrically. The samples will then dried in an oven for 10 days and a dry weight will be taken so the water content and density can be calculated. Samples may eventually also be analyzed for nitrogen and carbon content.

RESULTS



Slope	times	Moles of air			divided by wood weight (grams) or wood volume (m^3)			
(mole CO2)		(volume air (L))-x pressure (atm))				1		(wood volume is to check
(mole air-1 minute)		(.08206 L-atm/mole-degK)x(Temp(K))				(grams or m^3)		against soil respiration valu

Decay Class	Species	Wet wood weight	Dry wood weight	%water	Pressure	Temperature	Volume air
		(grams)	(grams)		(mbar)	(Celcius)	(Liters)
2	spruce	183.04			1010.45	27.35	12.8

Slope	slope	Moles air	1/wet weight	conversion	mgC	volume wood	conversion	gC	If 239 m^3 wood/h
(ppm/min)	(mol CO2/mol/min)		(1/g)	to mgC/hr	g wet wood*hr	(L)	L to m^3	m^3 wood*hr	then mgC/ m^2/hr
3.696	0.000003696	0.518032	0.005463287	720000	0.00753	0.2514	0.001	0.483	131.1

Decay Class	Species	mgC/g wet wood/hr	If 239 m^3 wood/ha then mgC/ m^2/hr
1	fir	0.06043	607.4
1	fir	0.04618	776.4
2	fir	0.00061	5.441
3	fir	0.02318	289.8
3	fir	0.01400	190.7
3	fir	0.03308	444.3
4	fir	0.07032	300.9
2	spruce	0.00753	131.1
2	spruce	0.01189	170.3
3	spruce	0.00578	69.81
3	spruce	0.00445	43.11

CONCLUSIONS

Deadwood respiration rates on an aereal basis were comparable to soil respiration rates reported for this forest ecosystem.

Unfortunately the summer was not long enough to obtain enough samples to come to any obvious conclusions. Eventually we would like to seek correlation between the respiration rate and temperature, water content, and the decay class within each species.